Thoughts about Remote Operation in a Global Accelerator Network (GAN):

Engineering Designs and Organizational Structures from the Engineer's and Operator's Point of View

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Introduction

The GAN approach describes an operation model for a large accelerator. Remote operation is a key element of the GAN philosophy.

What could technical commissioning as well as normal operation and error handling look like?

This will be analyzed based on the experiences and expectations of DESY hardware and software experts as well as experienced operators.

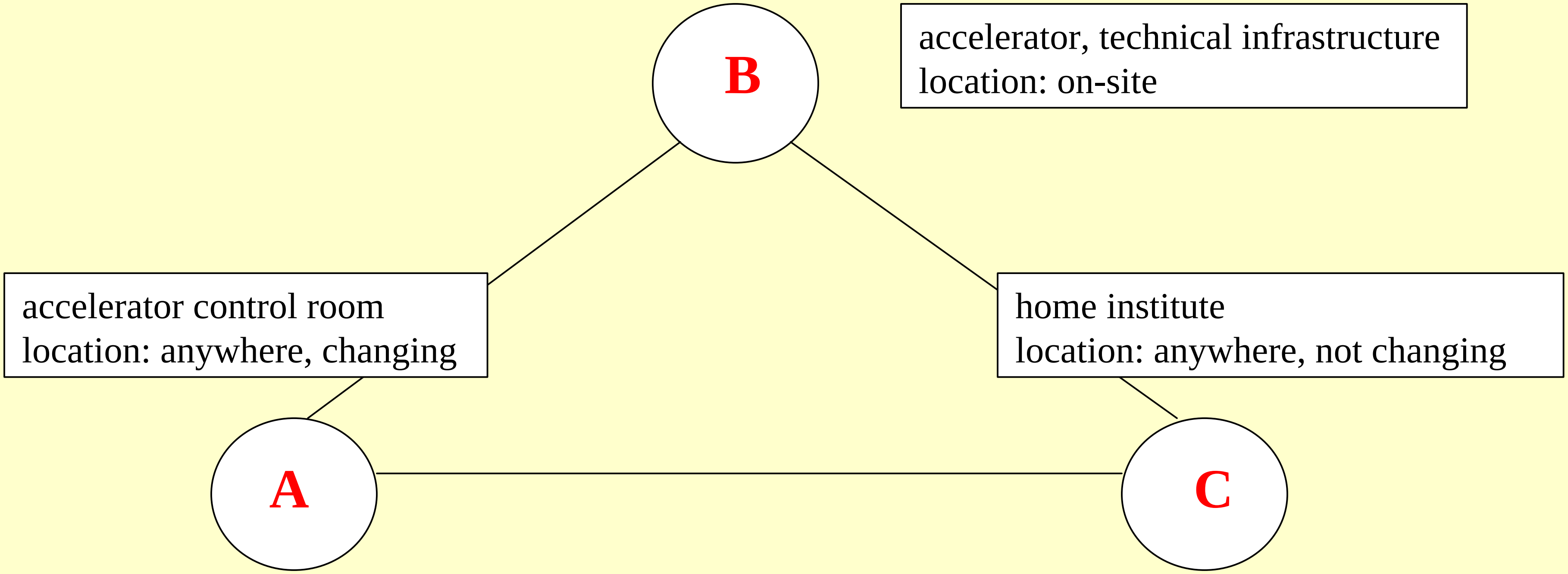
These conclusions are the basis to address the following questions:

- What factors concern all partners? And what factors are common to all partners?
- How important is the skill of the personnel involved? How important are “personal connections”?
- What are the necessary hardware design criteria for remote operation?
- What impact do the controls philosophy and the control system tools have?

N.B.:

This paper reflects the view of some DESY staff members. Its intention is to stimulate a discussion between accelerator and experimental staff of different institutes in order to learn and understand together the idea and the impact of the GAN remote operation model.

The GAN Operation Model



Collaboration of independent partners with equal rights and with their own culture, experience and history

Extensive remote operation of the facility according to a triangle-model

Long-term interest in the project and the preservation of special knowledge in the different home institutes by providing a

- system-oriented approach: one home institute is responsible for e.g. all RF systems or
- section-oriented approach: one home institute is responsible for e.g. the whole injector complex

depending on the ability of the institutes.

➢ It is not expected that the different approaches impose different general requirements on technology.

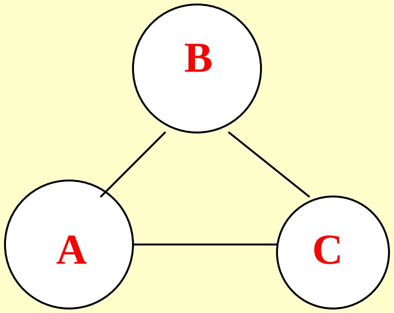
➢ The system-oriented approach could be more staff-size effective.

➢ The section-oriented approach could allow better staff sharing.

What technical commissioning could look like?

Accelerator control room (A):

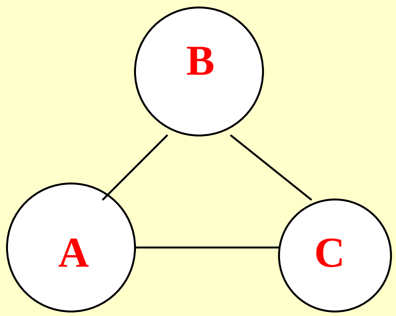
the operators are partially involved to bring in the operator's point of view in order to avoid too strong an influence of the technical experts on the design of the human-machine-interface



Accelerator, technical infrastructure (B):

pre-tested components will be installed, ultimately to be tested on-site and released by hardware/software experts temporarily on leave from C;

supported by contractors



Home institute (C):

almost all experts are temporarily at B

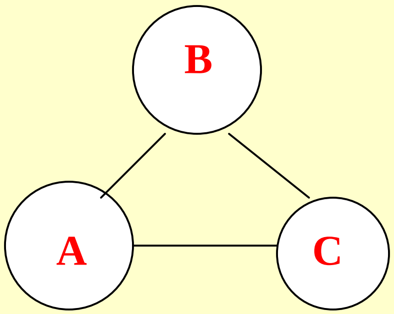
The fraction of experts in B and C will change gradually when the commissioning is finished and normal operations start.

What normal operation and error handling could look like?

Accelerator control room (A):

skills of staff:

engineers, accelerator physicists



tasks of staff:

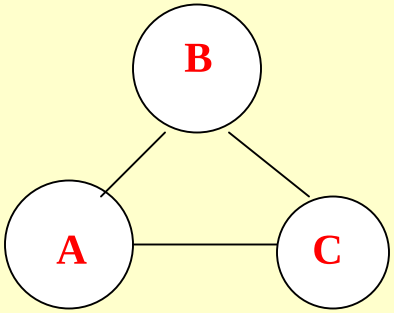
operate the accelerator,

initial failure analysis based on expert systems; if operators fail to resolve the problem, A informs B

Accelerator, technical infrastructure (B):

skills of staff:

experienced engineers and technicians, good local and special knowledge, permanently stationed on-site



necessary staff size:

≤ 100 persons (for 7x24h operations)

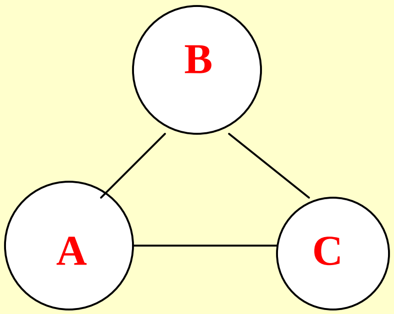
safety:

strict on-site responsibility for personal safety tasks of staff:

for simple, known or well documented problems, exchange of spare parts: on-site staff tries to solve the problem, supported by on-line documentation and expert systems

for complex or yet unknown problems: on-site staff tries to solve the problem together with the experts at C

for maintenance: done by on-site staff supported by contractors, coordinated by C



Home institute (C):

skills of staff: experienced engineers

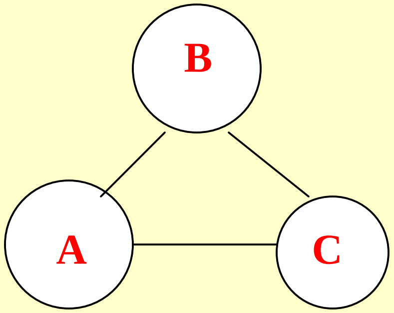
tasks of staff:

R&D work in order to improve the system performance and to prepare system upgrades

experts periodically monitor their system to keep it healthy

analyze the problem via remote diagnosis, organize the actions to be done by the on-site staff; if B fails, C has to go to B,

responsible for general planning, repair or procurement of broken equipment and availability of spare parts



How important are "personal connections"?

Experience shows that local "personal connections", personal contacts and mutual trust are vital for fast information flow and reactions.

- A crew has to be stationed permanently on-site to allow the "personal connections" among the personnel and the "back-door" pathways to establish themselves.

- A complete staff rotation between C (home institute) and B (accelerator, technical infrastructure) would be counter-productive for personal contacts but would keep the experts in C more involved and informed.

- Extended visits by selected experts from C at B could be a good compromise to preserve the "personal connections" between C and B.

Does GAN-like remote operation require a common infrastructure?

All partners have to agree on a common auxiliary infrastructure which has to be provided or to be supported:

• mains power, emergency power and battery back-ups

• water cooling and ventilation

• Ethernet network, secure access

• broad-band communication (audio and video) systems

• common on-line documentation system covering all technical information of the project

- common alarming system
- common logging system
- common accelerator control system interface or software bus standard

How important are a common operation philosophy and common quality standards?

Different partners have in general different operations philosophies and different experiences with quality standards.

It will be helpful to analyze, understand and anticipate the different approaches to get a common understanding and to gain from synergy effects.

Most important is the mutual trust in the common sense of those responsible.

- MTBF (mean-time-between-failure):

  could be a relevant parameter, but the common agreement on the best engineering practice is probably enough

  cannot be derived for unknown design or fabrication errors which according to experience are not trivial to detect and cause frequent interruptions of the accelerator operation when appearing

- error and operations statistics:

  must be very detailed, every event has to be investigated

  allows for early error detection before problem really appears

- safety standards:

  according to the rules of the on-site laboratory

• tests and maintenance:

pre-testing of equipment after production

burn-in-tests during commissioning

• preventive and scheduled maintenance:

has to be optimized for complex and expensive equipment

should be generous for “1-cent” equipment

• redundancy or automated error handling procedures:

keep operation interruptions at the lowest limit to minimize the resulting organizational effort, running costs and staff effort

risk of losing expert’s experience

What are the hardware engineering design criteria required for GAN-like remote operation?

- modularity:

  fast and simple exchange / repair scheme or redundant equipment

  separation of functions to simplify error detection or upgrades

- robustness:

  best engineering practice

  insensible to temperature, radiation, electro-magnetic noise

  watch-dog circuits

  ability for stand-alone operation

  intelligent and adaptable interlocks

- analog-to-digital conversion:

  conversion of all relevant analog hardware parameters

  external and internal clocking

- local intelligence:

  providing of all available digital data

  permanent or event triggered data logging of all relevant hardware parameters

  live self-checks and reports / statistics

  error detection and alarming

  programmable automation features

  on-line documentation

- interfaces:

  access via Ethernet to connect to the accelerator control system and special supervisory systems

  auxiliary access (on demand or at repair) via appropriate interfaces to connect e.g. mobile measurement or test equipment to get a real hardware-feeling

  standardized interfaces to other common equipment such as machine protection system

What impact do the controls philosophy and the control system tools have?

The control system has to satisfy the needs of the different users of the control system.

It is obvious that the needs of hardware or software experts who are responsible for technical subsystems will differ from the wishes of software experts who are responsible for control system integration and functionality.

The challenge will be to find the right balance to satisfy the different requirements, e.g.

- The earlier and more flexible the architecture and the functionality of the main "software bus" the higher will be the degree of acceptance by hardware designers and the possibility of a problem driven revision.

- The degree of standardization should be not too restrictive. It is unlikely that a common front-end system standard can be defined. Multiple interfaces besides the accelerator control system interface and a limited choice oft platforms and languages will allow hardware designers to write their own problem-oriented software.

- “Secret code” or “hidden variables” should not be allowed.
- A disastrous fragmentation has to be avoided because it places too much burden on the controls experts responsible for system integration.
- Popular industrial lab automation standards have to be supported.
- Generic tools such as server wizards or interfaces to alarming or logging systems have to be provided by the controls experts.